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POST~OPERATIVE WOUND INFECTIONS
IN
ORTHOPAEDIC SURGERY

The Department of Orthopaedic Surgery

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Illustration Department
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This dissertation is based on the following papers which will be referred to in the text by their Roman numerals:

- I Lidgren, L. and Lindberg, L. (1972) Orthopaedic infections during a 5-year period. Acta Orthop Scand 43:325.
- II Lidgren, L. and Lindberg, L. (1973) Post-operative wound infections in clean orthopaedic surgery. Acta Orthop Scand in press.
- III Ericson, C., Lidgren, L. and Lindberg, L. (1973) Cloxacillin in the prophylaxis of post-operative infections of the hip. J Bone Jt Surg 55-A:808.
- IV Ericson, C., Lidgren, L. and Lindberg, L. (1973) Cloxacillin in the prophylaxis of late infections in total hip arthroplasties (Addendum). J Bone Jt Surg 55-A:813.
- V Bergström, B., Lidgren, L. and Lindberg, L. (1973) Radiographic abnormalities caused by post-operative infection following total hip arthroplasty. Clin Orthop in press.
- VI Kamme, C., Lidgren, L., Lindberg, L. and Mårdh, P.-A. (1973) Anaerobic bacteria in late infections after total hip arthroplasty. Scand J Infect Dis in press.

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INTRODUCTION

Orthopaedic infections, i.e. infections of the bone and joints, often extending to the surrounding soft tissues, have long been regarded as being a class by themselves. Before the revolutionary studies of Pasteur and their application by Lister (1867) a little more than 100 years ago one third of all patients with open tibial fracture died (Bruns 1882). Today there is no mortality because of infection in this type of fracture and the incidence of osteomyelitis has in some material been reduced to less than 3 per cent (Edwards 1965).

However, it would seem that modern antiseptic and aseptic principles and during the last quarter of a century, antibiotic therapy have failed to reduce the over-all incidence of wound infections associated with orthopaedic operations. In the analysis of post-operative infection it is, however, important to compare the incidence of infection after each type of operation and not only the over-all infection rate. Kocher in 1899 reported a post-operative wound infection rate of 2.3 per cent in clean surgery. This figure is remarkably similar to the post-operative wound infection rate today. However, this similarity is misleading because it does not take into account the different type of patient involved today, and the more extensive surgical procedures, together with implantation of new osteosynthetic material. We can now carry almost all poor surgical risks through an operation, but we still have difficulties in keeping the risk of infection down to a reasonable level, although modern advances in medicine have succeeded in almost eliminating the mortality caused by wound infections. The infections often spoil the result of the orthopaedic operation with prolonged or permanent

disability, undersirable cosmetic results, and economic loss for the patients.

In a report from the Department of Orthopaedic Surgery in Malmö during 1963-1967 (Lidgren and Lindberg 1972) the mean duration of hospital-time of patients with major orthopaedic infections was 5 times the normal. This increase in length of stay is further magnified in respect to: the direct burden placed on the operation department with extra time incurred at every operation on infected patients, e.g. for special cleaning of the operating theatre and instruments; frequent dressings of the wounds; radiographic re-examinations; multiple laboratory testing; and management of potent antibiotic therapy with the accompanying risks. The extra costs for orthopaedic infections at the orthopaedic clinic in Malmö (a town of 260.000 inhabitants) are today, with a cost per patient per day of 552 crowns, probably considerably more than 1 million Swedish crowns per year, which gives a total amount for Sweden of at least 20 million crowns per year. The knowledge of these facts is important when planning measures to prevent and treat these infections, and to elucidate the demands placed on the hospital facilities.

In 1890 (Gluck) the first attempt was made to insert an endo-prosthesis (of ivory) in a knee-joint. The prevailing medical knowledge did not allow further trial. The first systematic attempts with total hip arthroplasty were performed in 1951 by McKee (1967). From 1958 bone cement (polymethylmetacrylat) and the low-friction prosthesis with polymethylene-acetabular-cup were successively introduced (Charnley 1970) and this has almost completely eliminated the risks of mechanical loosening (Charnley 1972, Weigert et al 1972, Lidgren et al 1973).

Today total hip arthroplasty according to the Charnley method presents few technical complications. The most serious problem remaining concerns the deep infections which appear with a frequency of 1 to 12 per cent in several series (Wilson et al 1969, Amstutz 1970, Ahlberg et al 1971, Charnley 1972, Harris et al 1972, Buchholz 1973). Such infections often make necessary the removal of the prosthesis, with permanent invalidism as a result.

Half of the infections become manifest later than 1 year after the operation (Charnley 1972). Months or years after operation pain at rest and/or at weight-bearing may appear, with local symptoms of infection or inflammation around the hip joint and possibly fistulation. Radiographic examinations show signs of osteitis with a radiolucency around the cement and often a periosteal reaction around the femoral prosthesis (Charnley et al 1967). Scintimetry with ^{85}Sr shows markedly increased activity (Bauer et al 1973).

Most authors seem to agree that most cases of deep infections which occur at an early stage post-operatively are caused by Staphylococcus aureus which probably invades the surgical site during operation (Ericson and Lidgren 1973). There are different opinions, however, about the etiology of the loosening of the prosthesis which occur at later stages. In many cases there is no bacterial growth when culturing on conventional media (Charnley 1972, Wilson et al 1972). This has brought forward the question as to whether the prosthesis alone could bring about an aseptic inflammatory reaction without the presence of bacteria (Wilson et al 1969, Wilson and Scales 1970, Wilson et al 1972). Charnley (1972) has claimed that the surgical site is contaminated during operation and that "late reactions" causing loosening of the prosthesis is in most cases the result of a slowly developing infection. Buchholz (1973)

on the other hand points out the possibility of an haematogenous dissemination of microorganisms and suggests that bacterial invasion may be encouraged by the presence of the prosthesis.

The orthopaedic infections still remain a serious problem and today the post-operative wound infections are in focus as a threat against further development of total joint arthroplasties.

Aims of the present studies

The studies were undertaken:

1. To classify all orthopaedic infections seen at a Swedish department of orthopaedic surgery in a well-defined population during a 5-year period (1963-1967) in respect to origin, age, sex distribution and anatomic location and to compare the material in certain respects with an uninfected series.
2. To report from the same department the number of post-operative infections where the following parameters were studied: age, anatomic location, and type of operation as well as whether the infection spoiled the result of the operation.
3. To determine if in a high-risk group of major operations in the hip, with insertion of foreign material, the frequency of post-operative infections could be reduced by prophylactic treatment with cloxacillin.

4. To determine if in a group of total hip arthroplasties according to Charnley the incidence of late infections or "late reactions" causing loosening of the prosthesis could be reduced by prophylactic treatment with cloxacillin.
5. To determine if in a clinically infected patient material operated with total hip arthroplasty according to Charnley there were specific radiographic abnormalities and to study the time relation between abnormalities and the initial symptoms of infection.
6. To study at re-operation, in a selected material of patients with "late reactions" after Charnley total hip arthroplasty, the presence of aerobic as well as obligate anaerobic bacteria. In the study were also included media for the isolation of L-phase variants of bacteria and mycoplasmas.

MATERIAL, METHODS AND RESULTS

Orthopaedic infections during a 5-year period in a quarter million population (I + II).

The investigation was carried out at the Department of Orthopaedic Surgery, Malmö General Hospital during 1963-1967. During this period all together 9 948 patients were admitted to the department. Of these, 357 were recorded as infected and form the probands of the present investigation.

All patients with clinical signs of infection of the skin, subcutaneous tissue, muscles or structures belonging to the bones and joints were recorded as orthopaedic infections. Here infections were classified as major when (1) they threatened or spoiled the results of operations, or (2) discharged exsudate for at least 1 month, or (3) prolonged the patient's stay in hospital by at least 1 month. In addition (4) all cases of osteomyelitis, including spondylitis, and infectious arthritis, were assigned to this group. 214 infections were classified as major and 143 as minor.

Material from infected wounds or joints was obtained for culture. In those cases where bacterial cultures were negative or not obtained, the infections were diagnosed on the basis of local inflammation, clinical course, elevated erythrocyte sedimentation rate, positive serological findings, prompt response to antibiotics, etc.

From 1965, patient data from Malmö General Hospital were processed in a computer and from these data it was possible to select a normal series consisting of all non-infected patients admitted to the orthopaedic clinic in 1965-1967. Comparison between the normal series and patients infected in the same years was therefore possible regarding sex, age, site of infection and data concerning operation.

During the entire 5-year period of investigation 1963 - 1967, 5 724 "clean" operations were performed on in-patients. Toward the end of 1972 all of the hospital records were studied to find out whether the infections had had any demonstrable effect on the late result of the operations.

Distribution of infections according to origin is given in Table 1.

Table 1.

Haematogenous	44
Traumatic	90
Post-operative from previous years	26
Post-operative 1963 - 1967	185
After injection into joint	8
Doubtful origin	4
	357

Of the 44 patients admitted with haematogenous infections, only 14 patients were below the age of 16.

In 90 patients admitted with infection caused by trauma other than ope-

rations, 74 occurred during 1963 to 1967, while the remaining 16 cases were recurrences or infections contracted earlier but not yet healed. The distribution was: osteomyelitis in 7 cases; open infected fractures in 18 cases; large, recent lacerations in 10 cases; soft tissue injuries "clean" on admission to hospital, 7 cases; soft tissue injuries "infected" on admission to hospital, 48 cases. No less than 15 per cent of all open

Of the 5 724 "clean" operations performed on in-patients, 185 (3.2 per cent) became infected and in 107 (1.9 per cent) the infections were classified as major. It was found that the frequency of post-operative infections increased significantly with age from less than 0.5 per cent below age 25 to close to 9 per cent above age 75. However, within a group of 219 cases of trochanteric femoral fractures operated with nail and plate with 32 post-operative infections, no increase in the infection rate with age was found. When comparing the anatomic location the hip joint was found to be a high-risk location; the spine and the knee joint were low-risk locations. The correlation of post-operative infection with different types of operations showed that the use of osteosynthetic material carried higher risks.

In 48 cases (26 per cent of the post-operative infections) the infection was considered to have spoiled the results of the operations. In 7 cases the condition of the patients was so severe before the operation, however, that the effect, of the infection could not be assessed with certainty. In 130 cases the infection had not affected the late result.

Cloxacillin in the prophylaxis of post-operative infections of the hip (III).

This investigation was carried out between November 1970 and May 1972. All the operations were performed at the orthopaedic clinics in

Lund or in Malmö. The double-blind technique was used and the patients were consecutively and randomly assigned to antibiotic or placebo groups. Three types of operations were included: 1/ total arthroplasty of the hip with the Charnley prosthesis, 2/ arthroplasty with the Moore endoprosthesis, and 3/ pertrochanteric or subtrochanteric femoral fractures fixed with a Thornton nail and plate. The series consisted of 230 consecutive patients operated on with any of the procedures above within the period covered by the investigation. Conventional media and methods were used for the isolation of bacteria.

The antibiotic used was cloxacillin (Ekvacillin, Astra, Sweden). The dosage was 1 gram given intramuscularly 1 hour before the operation and thereafter 3 times at 6 hour intervals followed by oral administration through the fourteenth day after operation. The placebo was given in the same way as the active substance.

A separate group of 134 patients at Lund with total hip arthroplasty, operated on before and after the investigation were studied retrospectively. Of the 134, 109 had received cloxacillin prophylactically in the same way as in the prospective investigation, and 25 had not received antibiotics prophylactically.

The results were evaluated in 171 of the 230 patients. Fifty-nine patients were eliminated from the investigation. The largest number of these had side effects, which occurred in 19 patients given cloxacillin and in 12 given placebo. Of the 171 patients in whom treatment was completed, infection occurred in 12 of 88 patients given placebo and in none of the 83 given cloxacillin. This difference was highly significant.

There was no significant difference in prevalence of infection in the clinics in Malmö and Lund, nor after the 3 different types of operation. Eight infections were regarded as superficial and 4 as deep. Staph. aureus was found in 10 patients including 1 together with Proteus mirabilis and another with Pseudomonas aeruginosa and Klebsiella. In the last mentioned patient, both the wound and the urinary tract were infected with Pseudomonas aeruginosa. In 1 patient repeated cultures revealed only Staph. epidermidis (albus).

Of the separate group of 134 patients at Lund with total hip arthroplasty, 109 had received cloxacillin prophylactically. It was found that 1 superficial wound infection with Escherichia coli and Proteus vulgaris had occurred in 1 of these patients in the prophylactic group. Of the 25 patients who did not receive prophylaxis, 5 were infected postoperatively, all with Staph. aureus. Four of these infections were superficial but in 1 case the infection resulted in extraction of the prosthesis 6 months after operation.

Cloxacillin in the prophylaxis of late infections in total hip arthroplasties (IV).

One year after the previous study was completed all patients from the same material (III) operated upon with total hip arthroplasty according to Charnley were reviewed in order to determine the effect of cloxacillin on the incidence of late infection or "late reactions" causing "loosening of the prosthesis". The observation time was 1 - 2 1/2 years after operation. This diagnosis required the following criteria:

- 1/ Pain at rest,during weight-bearing,or at all times.
- 2/ Erythrocyte sedimentation rate more than 40 mm/h (Westergren) while patient was not receiving antibiotics.
- 3/ A plasma electrophoretic pattern indicating a highly active process.
- 4/ Roentgenograms showing a periosteal reaction and a zone of bone resorption about the femoral or acetabular components, or both, more than 2 mm wide.
- 5/ Increased activity by ^{85}Sr about the components of the prosthesis.

According to the above criteria, late infections were demonstrated in 13 hips. In the 169 patients treated with cloxacillin there was 1 infection, while in the placebo-group there were 12 late infections in 83 patients, in addition to the early infections (III). These differences were highly significant.

Radiographic abnormalities caused by postoperative infection following total hip arthroplasty (V).

During the period March 1970 through June 1972, 283 total hip arthroplasties according to the Charnley method were performed at the Department of Orthopaedic Surgery in Lund. This material has been followed in a prospective series. All patients with persistent pain after operation have been reviewed clinically and radiographically and the complications have been reported (Bergström et al 1973). The observation time was 1 to 2 1/2 years after surgery.

For a description of the radiographic findings, the following terms were used:

Zone: Radiolucency between bone and cement or metal.

Scalloping: Irregularity of the zone greater than 2 mm.

Periosteal reaction: Localized irregular periosteal reaction without endosteal reaction.

Controls

Fifteen patients with bilateral operations were selected as a control group. If the first operated hip was said to be pain-free this hip was analysed. All these patients had an erythrocyte sedimentation rate below 40.

None of the 15 control hips showed development or increase of a zone after 6 months. One hip had a thin regular zone of 1 1/2 mm around the femoral component, visible before 6 months. In 9 other hips there was a thin regular zone 1 mm or less around the femoral component. In the additional 5 hips no zone was seen. Around the acetabular socket there was a thin zone in all hips less than 1 mm around some part of the cement, visible before 6 months and thereafter not showing any increase.

Infected patients

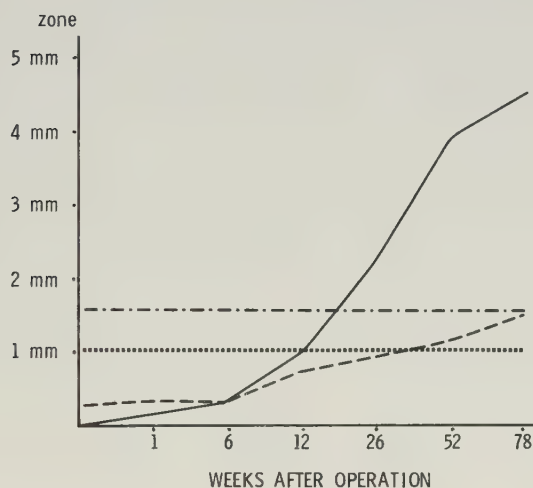
A diagnosis of infection was firmly established in a total of 14 patients. Two cases started immediately postoperatively as a deep wound infection, 2 presented late with fistulation, while the other 10 cases were diagnosed as infected according to the criteria reported in the previous paper (IV).

The development of a rapidly increasing zone in the 14 infected hips is shown separately for the acetabular socket and for the femoral component in Fig 1.

Fig 1.

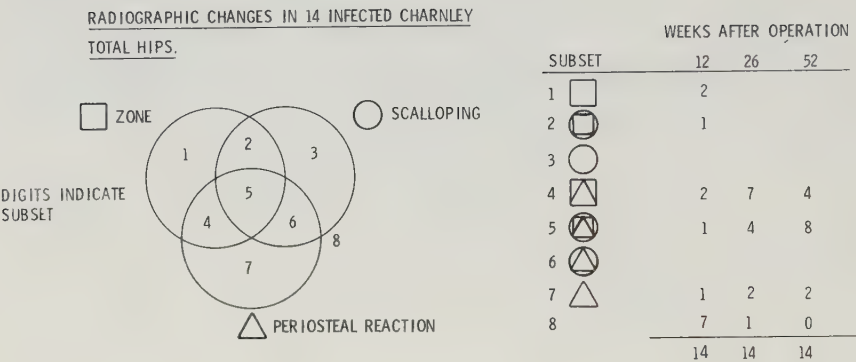
DEVELOPMENT OF RADIOLUCENT ZONE IN 14 INFECTED CHARNLEY TOTAL HIPS

AVERAGE ZONE – ACETABULAR SOCKET INFECTED HIPS: - - - - -
 - " - - FEMORAL COMPONENT INFECTED HIPS: —————
 MAXIMAL ZONE – ACETABULAR SOCKET NON INFECTED HIPS:
 - " - FEMORAL COMPONENT NON INFECTED HIPS: - . - . - .



Eight patients had continuous pain in the operated hip after operation. In these patients it took 3 – 6 months before the development of radiographic abnormalities indicating infection. The Venn-diagram in Fig 2 shows the frequency of periosteal reaction, zone and scalloping at 12, 26 and 52 weeks.

Fig 2.



Seven patients were re-operated and a comparison has been made between the operative findings and the roentgenological signs denoting looseness of the component, that is, if there was a zone more than 1 mm around the whole cement or if there was protrusion of the acetabular socket or sinking of the femoral component. The radiographic prediction was correct with regard to the femoral component in all cases. The acetabular socket, however, seemed radiographically loose in 2 cases, where it was found to be firmly seated, and in another case it seemed normal radiographically but was found to be loose at re-operation.

Eight arthrographies were performed. In 2 cases this gave more information than had been obtained by conventional radiography. In both cases contrast passed around the acetabular socket; at this time a thin regular zone less than 1 mm was seen.

Anaerobic bacteria in late infections after total hip arthroplasty (VI).

Seven patients with late infections from the same material as previously reported (V) and who underwent re-operation made up the material. Specimens of tissue were taken at re-operation for culture and microscopic examination (gram- and methylene-blue staining) from the area of the prosthesis in the acetabulum as well as in the femur. At the same time specimens were taken for histological examination of the joint fluid the acetabulum and the femur. Isolation of bacteria for cultures of aerobic and strictly anaerobic species, L-phase-variants and of mycoplasmas was performed. The anaerobic media were inoculated within 15 minutes after sampling. The determination of the in vitro susceptibility to cloxacillin of the isolated anaerobic bacterial strain was made. The agglutination reaction of the patient's serum to the strain which was isolated from the patient was carried out as a conventional Widal test.

The specimens yielded growth in 5 out of the 7 patients, viz. Staph. epidermidis (albus) in 1 case, and anaerobic bacteria in 4 cases. The anaerobic bacteria were identified as Propionibacterium acnes in 2 cases, as Peptococcus variabilis in 1 case, and as Peptococcus magnus in 1 case. The minimum inhibitory concentration (MIC) of cloxacillin was 0.5 µg/ml for 1 of the propionibacterium strains and 1.0 µg/ml for the 3 other anaerobic bacterial strains. In Table 2 the results of the serological examination are shown at the time of re-operation and 6 months later, for the 4 patients from whom anaerobic bacteria were isolated.

Table 2.

Titres of agglutinating antibodies against anaerobic bacteria isolated at re-operation of patients with late infections after total hip arthroplasty according to Charnley.

Patient No.	Isolated bacteria	Titre at time of re-operation	Titre 6 months after re-operation
1.	<u>Peptococcus magnus</u>	1/640 - 1/1280	1/80
2.	<u>Propionibacterium acnes</u>	1/320	< 1/20
3.	<u>Propionibacterium acnes</u>	1/80 - 1/160	< 1/20
4.	<u>Peptococcus variabilis</u>	1/160	1/160 - 1/320

In the 3 first patients clinical improvement was noted after removal of the prosthesis and antibiotic treatment with disappearance of pain at rest and absence of local signs of infection. The fourth patient did not continue the treatment with antibiotics instituted after re-operation and still had continuing pain at rest and local tenderness, suggesting an active infection.

DISCUSSION

During the past years the clinical course of haematogenous infection has changed in various respects. The acute form has become less common and the subacute form more so. (Winters and Cahen 1960, Harris and Kirkaldy-Willis 1967, Lidgren and Lindberg 1973). Of particular interest is the high frequency of infections appearing in adults. The observation of this shift is so recent (Bell 1968, Waldvogel et al 1970) and has apparently received such little attention that as late as 1967 it was stated in an editorial comment of the British Medical Journal that "osteomyelitis in the adult form from a cause other than injury is regarded as extremely rare". In our material 30 of 44 haematogenous infections have appeared in adults(1).

Of the patients with open fractures and joint injuries admitted immediately after the trauma, about 15 per cent become infected. The corresponding figure for patients with soft-tissue injuries was about 50 per cent(1). The reason this figure was so high was due mainly to the fact that these cases were already infected before admission. This group of infections is seldom treated as a separate group in the literature (Rockwood and O'Donoghue 1962). When these patients arrive at the hospital immediate institution of parenteral antibiotics in high doses must be regarded as clearly indicated.

The greater part of the orthopaedic infections consists of postoperative wound infections. The over-all post-operative wound infection rate in

"clean" orthopaedic surgery varies between 0.7 per cent (Jeljaszewicz and Bobr 1968) and 8.8 per cent (O' Riordan et al 1971). In most investigation it is between 2 - 5 per cent (Jeffrey and Sklaroff 1958, Henderson and Kornblum 1961, Schonholtz et al 1962, Annals of Surgery 1964, Maguire 1964, Räf 1964, Stevens 1964, Dencker 1965, Towers 1965, Derian and Green 1966, Zifko and Vlasich 1968, Bruun 1970). About half of the infections have been recorded as major (Tachdjian and Compere 1957, Maguire 1964, Räf 1964, Derian and Green 1966, O' Riordan et al 1971). In our material the over-all infection rate was 3.2 per cent and in 1.9 per cent the infection was classified as major (II). This does not differ from what has been reported by other authors.

A large number of factors believed to increase the frequency of post-operative infection have been analysed by several investigators. In a few investigations attempts have been made statistically to correct for possibly interfering background factors. An increase of post-operative infections has thus been shown with age, duration of pre-operative hospitalisation, co-existing infection else-where (e.g. of the nose, skin, urinary tract), type of pre-operative washing, anatomic location, type of operation, duration of operation, length of incision, drainage, the number of persons present in the operating theatre, and the time of day the operations are performed. (Tachdjian and Compere 1957, Lancet 1960, Henderson and Kornblum 1961, Annals of Surgery 1964, Räf 1964, Stevens 1964, Gillquist 1967, Jeljaszewicz and Bobr 1968, Bruun 1970). Annals of Surgery (1964) reported a significant increase of post-operative infections in patients with malnutrition, overweight, and diabetes and in patients undergoing steroid treatment, while Stevens (1964) and Bruun (1970) found no increase for these patients. We have previously reported that the incidence of post-operative infections in patients with diabetes or rheumatoid arthritis was not increased (Lidgren 1973 a,b).

In our material (II) the following parameters have been analysed: age, anatomical locations and type of operation. In the whole material of post-operative wound infections there was a significant increase with age. However, within a group of trochanteric femoral fractures no increase in the incidence of post-operative infections with increasing age could be found. It was clear that operations in the hip regions together with insertion of osteosynthetic material not only significantly increased the incidence of post-operative infections but also accounted for no less than 60 per cent of all post-operative infections and half of the spoiled results after operation. Major operations on the hip should serve as a highly sensitive indicator of the possibility of reducing post-operative wound infections by whatever route of bacterial contamination. This made us choose this operation in order to see if prophylactic treatment with antibiotics could reduce the incidence of post-operative wound infections.

The question of the values of antibiotics in the prevention of post-operative infection is moot. Several investigators have found that routine prophylactic use of antibiotics increases the frequency of infections (Tachdjian and Compere 1957, Schonholtz et al 1962, Johnstone 1963, Annals of Surgery 1964, Maguire 1964, Derian and Green 1966). Others have found that antibiotics either lower the frequency (Alexander et al 1960, Forbes 1961, Kornfield and Allbritten 1961, Ketcham et al 1962, Ketcham et al 1963, Bingham 1967, Feltis and Hamit 1967, Fogelberg et al 1970) or have no effect (McKittrick and Wheelock 1954, Appleton and Waisbren 1956, Sanchez-Ubeda et al 1958, Rocha 1962). All the differences in the composition of the clinical material, indications, the choice of antibiotic and dosage as well as in the bacterial flora and in the type of operation and anatomic region of the

operation may pertain. Our success with cloxacillin in reducing the incidence of post-operative infection (III) may have depended on several pre-conditions: Staphylococcus aureus was the predominant pathogenic organism found in specimens from postoperative wound infections at the hospital and all strains known to occur in the environment were susceptible to methicillin (Ericson and Lidgren 1973); the administration of cloxacillin given 1 hour before operation is long enough for the antibiotic to reach a high concentration in the blood and soft tissue and therefore also in the wound cavity, hematoma and secretion in the operative field (Lindberg 1969, Wysochi et al 1970, Bowers et al 1973). It should be borne in mind that the good results obtained in our investigation in the type of operation studied are not valid in epidemiological circumstances differing essentially from those prevailing in our hospital at the time this study was done.

An important question was if prophylactic treatment with cloxacillin also could reduce the incidence of "late reactions" in total hip arthroplasties. Earlier reports argue for an infectious etiology and against the belief that the inflammatory process results only from a tissue reaction against the prosthesis. Thus Charnley (1972) has accounted for 20 patients with bilateral operations in whom loosening of the prosthesis occurred only unilaterally. Patients with "late reactions" can also show clinical regress as a result of therapy with antibiotics (Amstutz 1970). Adaption of strict surgical routines reduces the frequency of early infections as well as "late reactions" (Charnley 1972, Todd et al 1972). This also argues for the route of entrance being the same in the late as in the early infection and against the idea that a haematogenous dissemination of the bacteria to the surgical sites occurs postoperatively.

In our material (IV) it was shown that cloxacillin significantly reduced the incidence of "late reactions" in total hip arthroplasties. Our data further strengthen the fact that "late reactions" in most cases are slowly developing infections.

It should then be of great diagnostic and therapeutic value if the long time-lag between bacterial invasion and manifest infection could be shortened by more careful analysis of the radiographic signs of infection. Most authors described the radiographic abnormalities in these cases only as osteitis and the time relation between symptoms and radiographic abnormalities is rarely mentioned. Charnley et al (1967) and Chapchal and Müller (1970), however, have stated that approximately half of the normal cases show same "condensation of cancellous bone demarcating the external surface of the cement". This appearance is said to be evident only 1 - 2 years after the operation; thereafter this zone would not seem to increase significantly, i.e. it would rarely become thicker than 1 mm, measured directly on the radiograph with most of it related to the distal part of the cement. These findings are not in agreement with our results (V) in the non-infected group where the zone, when present was observed before 6 months and thereafter did not increase. Our findings are, however, in accordance with histologic investigations performed by Slooff (1971); the partial necrosis after operation between bone and cement starts approximately after 2 months, to slowly disappear and is replaced by fibrous tissue and new bone in the immediate proximity of the cement. After 4 to 6 months Slooff observed complete restoration.

We observed that the zone in the infected group rapidly increased after 6 weeks and continued to increase even after 6 months. This was most

evident at the femoral component. Occasionally radiographic signs of infection become very obvious, but this is not the rule. Rather, in 2 of our 14 cases a periosteal reaction was the only radiographic sign of infection even 1 year after operation. However, already at 12 weeks, 6 cases had developed a zone and 2 of these had scalloping. At 52 weeks, 8 of the 14 cases had developed all of the 3 signs of infection; a periosteal reaction, an increased radiolucent zone and scalloping.

The result of the study in the reoperated cases(VI) confirmed that the genesis of "late reactions" following total hip arthroplasty is infectious and that anaerobic bacteria are often involved. Whether the post-operative infection after total hip arthroplasty occurs early (without wound healing per primam) or late (with wound healing per primam) would seem to depend on which bacteria are contaminating the surgical site and whether this bacteria can establish an infection there. Staph. aureus produces early infections (III) whereas anaerobes and aerobic bacteria with a low virulence can have a long period of latency before symptoms appear. The mere presence of the prosthesis may encourage bacteria deposited at the surgical site to establish an infection there. Mechanical instability and increased intraosseous pressure may also decrease the local resistance to infection (Arnoldi and Buhl 1973, Olerud 1973).

Charnley (1972) has attributed great importance to the risk of transferring bacteria from the operation team to the patient. However, the bacteria causing post-operative infections can also originate from the patients themselves. It is a well known fact that a patient who is

carrying Staph. aureus in the nose often contaminates his own hair and skin with this bacterium. The skin at the hip joint is usually also heavily contaminated with bacteria found in the patient's intestinal flora, the greater part of which consists of anaerobic bacteria (Moore et al 1969). It is plausible that the anaerobes that were isolated in the present study originated from the patients and not from the environment. Therefore, in the prevention of infection a major aim should be a thorough pre-operative preparation of the patient (Lidgren and Rasmussen 1973). Attempts to isolate the bacteria causing late infections should be made from specimens taken by aspiration from the hip joint or by fenestration from the resorption zone around the femoral component. (Salvati et al 1971, Arnoldi and Buhl 1973). Determination of the in-vitro sensitivity of the isolated strain will then be the basis for the choice of drug. The examination for the presence of agglutinating antibodies in the patient's serum against the isolated strain can be of value both in establishing the diagnosis and in evaluating the results of treatment.

SUMMARY

All patients with orthopaedic infections admitted to the Department of Orthopaedic Surgery in Malmö during the period 1963 - 1967 were classified with respect to origin, age, sex, and the site of infection, and in certain respects compared with the non-infected patient material from the same time. The total number of infections was 357. Thirty of the 44 haematogenous infections were found to have appeared in adults 90 infections were caused by trauma other than operation; 185 infections were caused by "clean operations", corresponding to 3.2 per cent post-operative infections; 107 of the post-operative infections were classified as severe. The incidence of infection was highest for operations in the hip region, which accounted for no less than 60 per cent of all post-operative infections and half of the spoiled results of the operation. Only in 2 cases was the orthopaedic infection apparently the cause of death.

In 2 separate hospitals, it was shown in a double-blind study of 171 hip operations that prophylactic treatment with cloxacillin significantly reduced the frequency of early post-operative infections. The first group receiving prophylactic cloxacillin had no post-operative infection, while the second, placebo group had 12 (in 88 patients). All of the patients had major surgery to the hip and 10 of the 12 infections were caused by Staphylococcus aureus. We also observed a significant reduction in the same material of "late reactions" following total hip arthroplasties according to Charnley.

The radiographic signs of infection in 14 patients with Charnley total hip arthroplasties were compared with a non-infected control group. It was found that half of the non-infected hips developed a radiolucent zone around the femoral component. However, this zone never increased in width beyond 6 months post-operatively and was always less than 2 mm in width. In comparison with the control hips, 6 of the infected hips had developed a zone wider than 2 mm as early as 12 weeks post-operatively, and 2 of these had scalloping of cortical bone. By 52 weeks, all infected hips had clear radiographic signs of infection. Radiographic prediction of looseness of the components was found to be correct at re-operation for all femoral components but false for 3 acetabular sockets in 7 re-operated cases.

At re-operation of 7 patients with late infection following total hip arthroplasty according to Charnley, obligate anaerobic bacteria were isolated from 4 of the patients. Staph. epidermidis (albus) was isolated in 1 additional patients. 2 of the patients from whom no bacteria were isolated were on antibiotic therapy at the time of re-operation. In 3 of the 4 patients from whom anaerobic bacteria were isolated, a significant decrease in the titre of agglutinating antibodies against the patient's own strain was observed 6 months after re-operation and antibiotic treatment.

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